BOOK OF ABSTRACTS

6th International Conference on the Dynamics of Information Systems (DIS 2023)

September 3–6, 2023, Prague, Czech Republic


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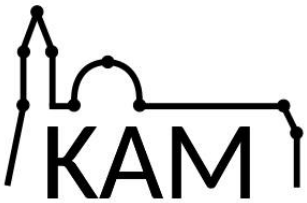
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Introduction

Welcome to the 6th International Conference on Dynamics of Information Systems (DIS 2023)! This book offers a preview of the exciting research that will be presented at the conference, taking place from September 3rd to 6th, 2023, in Prague, Czech Republic.

DIS 2023 continues the legacy of a successful series that has explored the realms of information science, optimization, operations research, machine learning, and artificial intelligence. This conference serves as a convergence point for scholars, researchers, and practitioners from around the world, gathering to discuss, share, and shape the future of information systems.

Within this book, you will find summaries of the talks and presentations scheduled for the conference. These summaries, known as abstracts, provide concise descriptions of the topics that each presenter will address.

The authors of these abstracts come from various backgrounds, such as science and engineering. They have invested significant effort in comprehending and resolving the challenges within information systems. The abstracts offer you a glimpse into their work and the subjects they will explore during the conference.

We hope everyone has a really productive time and believe that the conference will provide lots of inspiration, leading to important progress in your specific research areas.

General Chairs of DIS 2023

- Panos M. Pardalos, University of Florida, USA
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https://dis2023.ujep.cz/

Invited Speakers

Quantifying Model Uncertainty for Semantic Segmentation Using RKHS Operators

Jose C. Principe, University of Florida, USA

This talk presents our current goal of developing operators inspired by quantum theory to quantify uncertainty in the outputs of machine learning models, specifically semantic segmentation. The basic observation is that data projected to a Reproducing Kernel Hilbert Space (RKHS) with kernels built from the expected value operator are statistical embeddings of the input data. At the same time, the RKHS functionals obey the properties of a potential field. Therefore, one can directly apply the Schrodinger equation to the projected data and interpret its Hermite expansion in terms of modal decompositions of the PDF over the space of samples that express multi scale uncertainty. This methodology is quite general and can be used in many different applications as demonstrated in the talk.

Towards a Dynamic Value of Information Theory

Roman Belavkin, Middlesex University London, England

The value of information (VoI) theory was developed in the 1960s by Ruslan Stratonovich and colleagues. Inspired by Shannon's rate distortion theory, it defines VoI as the maximum expected utility (or the minimum expected cost) that can be achieved subject to a given information constraint. Different value functions correspond to different types of information and different optimal Markov transition probabilities. In many natural systems, such as learning and evolving systems, the information amount itself is dynamic, and here we discuss dynamical extension of the value of information theory. We formulate the corresponding variational problems defining certain geodesic curves on statistical manifolds and discuss the resulting theory. Examples for Shannon's information and certain types of utility functions will be used for illustration. The problem of optimal control of mutation rates in evolutionary systems will be considered as an application of the theory.

Diffusion Capacity of Single and Interconnected Networks

Panos Pardalos, University of Florida, USA

This lecture addresses the significant challenge of comprehending diffusive processes in networks in the context of complexity. Networks possess a diffusive potential that depends on their topological configuration, but diffusion also relies on the process and initial conditions. The lecture introduces the concept of Diffusion Capacity, a measure of a node's potential to diffuse information that incorporates a distance distribution considering both geodesic and weighted shortest paths and the dynamic features of the diffusion process. This concept provides a comprehensive depiction of individual nodes' roles during the diffusion process and can identify structural modifications that may improve diffusion mechanisms. The lecture also defines Diffusion Capacity for interconnected networks and introduces Relative Gain, a tool that compares a node's performance in a single structure versus an interconnected one. To demonstrate the concept's utility, we apply the methodology to a global climate network formed from surface air temperature data, revealing a significant shift in diffusion capacity around the year 2000. This suggests a decline in the planet's diffusion capacity, which may contribute to the emergence of more frequent climatic events. Our goal is to gain a deeper understanding of the complexities of diffusive processes in networks and the potential applications of the Diffusion Capacity concept.

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Schieber, T.A., Carpi, L.C., Pardalos, P.M. et al. Diffusion capacity of single and interconnected networks. Nat Commun 14, 2217 (2023). https://doi.org/10.1038/s41467-023-37323-0 (see also supplementary information)

Schieber, T., Carpi, L., Díaz-Guilera, A. et al. Quantification of network structural dissimilarities. Nat Commun 8, 13928 (2017). https://doi.org/10.1038/ncomms13928

Search in Imperfect Information Games

Martin Schmid, Google DeepMind, Canada

From the very dawn of the field, search with value functions was a fundamental concept of computer games research. Turing's chess algorithm from 1950 was able to think two moves ahead, and Shannon's work on chess from 1950 includes an extensive section on evaluation functions to be used within a search. Samuel's checkers program from 1959 already combines search and value functions that are learned through self–play and bootstrapping. TD–Gammon improves upon those ideas and uses neural networks to learn those complex value functions — only to be again used within search. The combination of decision–time search and value functions has been present in the remarkable milestones where computers bested their human counterparts in long standing challenging games–DeepBlue for Chess and AlphaGo for Go. Until recently, this powerful framework of search aided with (learned) value functions has been limited to perfect information games. We will talk about why search matters, and about generalizing search for imperfect information games.

RealOpt-Contingency – A Computational Platform for All Hazard and Disaster Response

Eva K Lee, Georgia Institute of Technology, USA

Catastrophic calamities such as an earthquake, nuclear or pandemic disasters, or deliberate terrorist attacks could cause tens or hundreds of thousands of casualties, destroy the physical and social livelihoods of the displaced, paralyze the economy, and trigger cascading effects across critical infrastructures and national security. In response, rapid decisive actions and mobilization of limited resources must be carried out for mass casualty mitigation and population protection. This work aims to advance applied scientific knowledge, and in-service training in national and public health emergency response and logistic operations by developing a computational platform, RealOpt-Contingency, that enables logistics analysis, inventory management, and computational modeling technologies to support all hazard and disaster response during a contingency. RealOpt-Contingency enables users to (1) establish camps and medical facilities for the affected population; (2) design facility layout for optimal usage and safety; (3) optimize distribution of relief supplies; (4) determine rations, water, fuel, and other supplies required per camp and medical facilities; (5) calculate transportation labor and resource requirements, and determine/optimize routes; (6) develop distribution plans from the incident LSA to LSA hubs and to camps and medical facilities; (7) design decontamination and dispensing sites; (8) perform epidemiological disease/contamination plume modeling; and (9) track movement of displaced personnel for rapid on-the-ground reconfiguration. The front-end graphical interface allows users to outline the affected region, design layout of facilities, input inventory level, demand requests, estimated population size, etc. The backend translates this information automatically into appropriate mathematical formulations and simulation parameters. RealOpt-Contingency includes powerful computational-optimization engines including multiple resource allocation, transportation and routing algorithms, simulation and ODE disease spread modeling, facility layout design heuristics, inventory control stochastic processes, and machine learning and prediction of influence networks. The modular design allows continued technological advances and adaptation using on-the-ground knowledge. RealOpt-Contingency facilitates experimentation, operations analysis, and decision support for preparedness, planning, and response, enabling decision/policy makers to understand tradeoffs, competing goals, and interdependencies during disaster emergency response. We will discuss actual usage of RealOpt-Contingency for (a) COVID-19 mass diagnostic tests, mass vaccination, and clinical redesign; (b) radiological emergency response for sheltering, resupply, decontamination, and population health registry; and (c) earthquake emergency response, rescue and treatment.

This work was carried out in collaboration with the National Guard Bureau and was partially supported by the Centers for Disease Control and Prevention, and the Department of Homeland Security.

Regular Papers

A Collaborative Multi-Objective Approach for Clustering Tasks Based on Distance Measures and Clustering Validity Indices

Beatriz Flamia Azevedo, Instituto Politecnico de Bragança, Portugal

Ana Maria A. C. Rocha, University of Minho, Portugal

Ana I. Pereira, Instituto Politecnico de Bragança, Portugal

Clustering algorithm has the task of classifying a set of elements so that the elements within the same group are as similar as possible and, in the same way, that the elements of different groups (clusters) are as different as possible. This paper presents the Multi-objective Clustering Algorithm (MCA) combined with the NSGA-II, based on two intra- and three inter-clustering measures, combined 2-to-2, to define the optimal number of clusters and classify the elements among these clusters. As the NSGA-II is a multi-objective algorithm, the results are presented as a Pareto front in terms of the two measures considered in the objective functions. Moreover, a procedure named Cluster Collaborative Indices Procedure (CCIP) is proposed, which aims to analyze and compare the Pareto front solutions generated by different criteria (Elbow, Davies-Bouldin, Calinski-Harabasz, CS, and Dumn indices) in a collaborative way. The most appropriate solution is suggested for the decision-maker to support their final choice, considering all solutions provided by the measured combination. The methodology was tested in a benchmark dataset and also in a real dataset, and in both cases, the results were satisfactory to define the optimal number of clusters and to classify the elements of the dataset.

Dispersion of Personal Spaces

Jaroslav Horáček, Charles University, Faculty of Humanities, Department of Sociology, Prague, Czech Republic

Miroslav Rada, Prague University of Economics and Business, Faculty of Informatics and Statistics, Department of Econometrics, Prague, Czech Republic- Prague University of Economics and Business, Faculty of Finance and Accounting, Department of Financial Accounting and Auditing, Prague, Czech Republic

There are many entities that disseminate in the physical space – information, gossip, mood, innovation etc. Personal spaces are also entities that disperse, interplay and arrange. In this work we study the emergence of configurations formed by participants when choosing a place to sit in a rectangular auditorium. Based on experimental questionnaire data we design several models and assess their relevancy to a real time lapse footage of lecture hall being filled up. The main focus is to compare the evolution of entropy of occupied seat configurations in time. Even though the process of choosing a seat is complex and could depend on various properties of participants or environment, some of the developed models can capture at least basic essence of the real processes. After introducing the problem of seat selection and related results in close research areas, we introduce preliminary collected data and build models of seat selection based on them. We compare the resulting models to the real observational data and discuss areas of future research directions.

An Efficient Heuristic for Solving the General-Product Structure Assemble-to-Order Systems

Mohsen Elhafsi, University of California-Riverside, United States

Essia Hamouda, California State University, San Bernardino, United States

Jianxin Fang, Xi'an Jiaotong - Liverpool University, China

Assemble-to-order (ATO) strategies are appealing to manufacturing firms that seek to be responsive while being cost effective. By staging inventory of components ahead of demand and postponing product assembly until customer demand materializes, an ATO strategy enables a firm not only to shorten its response time to its customers, but also to reduce its cost of offering a high product variety by pooling component inventories. ATO strategies are common to many industries. Examples of such industries include the computers industry, such as the online ordering segment of Dell and the server build-to-order strategy of IBM; the automotive industry, such as the build-to-order strategies of Toyota and General Motors; and the online retailing industry, such as L.L. Bean and Amazon.com.

General product structure ATO systems are difficult to analyze. Such difficulty emanates from several factors: demand fulfillment requires the simultaneous availability of several components; components may be common to several products; and production/procurement leadtimes may differ from one component to another. These factors make it very challenging to address, simultaneously, component coordination and component allocation among competing products.

Despite a large body of literature, optimal operating policies have been characterized only for few special-product structure ATO systems, such as M-, W- and Nested-product structures (see Atan et al. (2017) and the references there in). Still, such optimal policies can be obtained numerically, only for systems with moderate number of components.

We consider a general-product structure ATO problem modeled as an infinite horizon Markov decision process. We develop a heuristic policy that is based on a decomposition of the original system, into series of two-component ATO subsystems. We show that our decomposition heuristic policy (DHP) possesses many properties similar to those encountered in special-product structure ATO systems. Extensive numerical experiments show that the DHP is very efficient. In particular, we show that the DHP requires less than 10^{-5} the time required to obtain the optimal policy, with an average percentage cost gap less than 4% for systems with up to 5 components and 6 products. We also show that the DHP outperforms the state aggregation heuristic of Nadar et al. (2018), in terms of cost and computational effort. We further develop an information relaxation-based lower bound on the performance of the optimal policy. We show that such a bound is very efficient with an average percentage gap not exceeding 0.5% for systems with up to 5 components and 6 products. Using this lower bound, we further show that the average suboptimality gap of the DHP is within 9% for two special-product structure ATO systems, with up to 9 components and 10 products. Using a

sophisticated computing platform, we believe the DHP can handle systems with a large number of components and products.

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The Effects of an Earnings-Based Covenant on Capital Structure and Firm Value

Michi Nishihara, Osaka University, Japan

Takashi Shibata, Tokyo Metropolitan University, Japan

This paper studies a dynamic capital structure model with an earnings-based covenant that forces a firm to maintain the ratio of debt to earnings within an upper limit. The equity, debt, firm values, as well as optimal capital structure are derived explicitly. For low levels of the upper limit, shareholders prefer to retire debt rather than default whenever the debt-earnings ratio exceeds the upper limit. That is, debt reduction occurs whenever earnings hit a record low, and debt is riskless. Then, because of no bankruptcy costs, the firm optimally chooses the maximum debt level within the covenant to maximize the tax benefits of debt. The tradeoff between the gain from no bankruptcy costs and loss in the tax benefits by debt reduction determines whether the covenant increases the firm value. The covenant tends to increase the firm value for a higher bankruptcy cost, corporate tax rate, and volatility, as well as a lower growth rate.

Optimizing the Performance of Financial Vehicles Using DEA

Maryam Badrizadeh, State University of New York at Farmingdale, United States

In this study, Data Envelopment Analysis (DEA) has been used for evaluating the performance of investment vehicles such as pension funds, mutual funds and hedge funds. DEA is a powerful analytical approach with specific characteristics that considers the effect of multiple variables at the same time. Also, the main specifications such as regulations, taxation system, contributions of pension funds and mutual funds are considered and different DEA models are utilized for comparing these type of funds. The pension funds and mutual funds are compared directly and indirectly. In the direct comparison, both pension funds and mutual funds are optimized as one data set while considering the specific characteristics of each type of funds. In the indirect comparison these two funds are bridged and optimized together with two distinct data sets. The results show that considering the differences for each type of funds by using DEA prevents the overestimation or underestimation of the performances and provides a more realistic comparison amongst pension funds and mutual funds. For this study data from Canadian pension funds and Canadian mutual funds were used. The analytical models can be used for different type of datasets and industries.

A Cluster-Based Heuristic Method for Private Car Sharing

Zeliha Ergul Aydin, Eskisehir Technical University, Turkey

Banu Icmen Erdem, Eskisehir Technical University, Turkey

Zeynep Idil Erzurum Cicek, Eskisehir Technical University, Turkey

Car sharing is a transportation approach that involves individuals who share comparable travel routes and opt to travel together using shared cars from specific starting points to designated destinations. Car sharing has become an increasingly popular mode of transportation in recent years due to its environmental and economic benefits. Private car sharing has emerged as a promising solution to reduce the negative environmental impacts and high costs associated with individual car ownership. However, privacy concerns have limited the adoption of car-sharing systems, particularly those that involve private car owners. This study presents a novel approach to optimize private car sharing, which is a promising solution for reducing the overall distance traveled and providing fair wear and tear between users. The proposed method clusters individuals based on their home and work locations and creates car-sharing groups by considering whether people have a vehicle or not and the capacity of cars. The clusters are then optimized using a heuristic algorithm that minimizes the distance traveled and ensures fair wear and tear between used cars. The algorithm's effectiveness is evaluated through simulation experiments based on real-world data from a city in Eskisehir, Turkey. In these experiments, we considered a group of people working in the same workplace, and not everyone owning a private car. The results demonstrate that the proposed method can significantly improve the efficiency of private car sharing, reduce distance, and increase the satisfaction of both car owners and passengers.

Designing Networks Resilient to Clique Blockers

Foad Mahdavi Pajouh, Stevens Institute of Technology, United States

Haonan Zhong, Kunming University of Science and Technology, China

Oleg Prokopyev, University of Pittsburgh, United States

The concept of vertex blockers is often used for robustness and vulnerability analysis of networked systems. In the minimum cost vertex blocker clique problem, we seek a subset of vertices with the minimum total blocking cost such that the weight of any remaining clique in the interdicted graph is bounded above by some desired parameter. We aim at disrupting the network with the minimum possible cost to guarantee that the network does not contain cohesive (e.g., closely related) groups of its structural elements with large weights; such groups are modeled as weighted cliques. In this talk, our focus is on designing networks that are resilient to clique blockers. Specifically, we aim to construct a minimum cost subset of additional edges in the network to ensure that the adversarial decision-maker cannot efficiently disrupt the network by limiting the weight of its cohesive groups. The proposed approach is useful for modeling effective formation and preservation of influential clusters in networked systems. We first explore structural properties of our problem. Then, we develop several exact solution schemes based on integer programming and combinatorial branch-and-bound techniques. Finally, the performance of our approaches is explored in a computational study with randomly-generated and real-life network instances.

Exploiting Monge-Like Properties in Optimisation Problems under Interval Uncertainty

Martin Cerny, Department of Applied Mathematics, Faculty of Mathematics and Physics, Charles University, Czechia

Many optimisation problems, e.g. the travelling salesman problem, are computationally difficult to solve in general. However, efficient algorithms can be found if we assume further properties. For other problems, e.g. the transportation problem, the presence of such properties lead to algorithmical speed ups. An instance of such properties are Monge-like properties and there is a vast research on their algorithmical aspects. All these results become useless when uncertainty in data occurs. It can be caused by data corruption, imprecisions in data measurement or by floating-point arithmetics.

These problems are often dealt with by encapsulating real values by real closed intervals and further working with them. In our work, we investigate the Monge-like properties under interval setting. First, we define two variants of the properties and spend some time analysing them. We present different characterisations and recognition algorithms. Second, we try to extend the well-known algorithmical aspects of the properties (for real values) into interval setting.

Heuristic Algorithms for the Multistage Flowshop Scheduling Problem

Kyriakos Bitsis, University of Macedonia, Greece

Konstantinos Kaparis, University of Macedonia, Greece

Optimal scheduling is among the most vital aspects of any efficient and effective production line in pursuing sustainability and competiveness of organizations. We consider the production of a steel reinforcement manufacturer in UK and we develop a Mixed Integer Programming (MIP) formulation for a multistage flexible flow shop scheduling problem with parallel unrelated machines in each stage. The proposed model takes into account machine dependent setup times, due and release times while the jobs do not have to be processed through all stages. The missing operations usually exist in many real-life production systems such as stainless steel manufacturing companies. The objective function is the minimization of makespan or lateness depending on the user's need. Anomaly detection plays a vital role in the overall scheme and re-optimization strategies are implemented to respond to such requests. The essential complexity of the problem necessitates the application of a constructive heuristic (CH) for the cases where a feasible solution is needed in a short amount of time, while the application of a Simulated Annealing (SA) meta-heuristic it's imperative for cases where an adequate resolution period allows a better solution to be found. The proposed SA algorithm uses as starting point the solutions that are indicated by the constructive heuristic while the solution of the former is used as a initial solution for the proposed MIP. Both CH and SA are compared with the optimal solutions of MIP and as a result SA algorithm is efficient in finding out good quality solutions for the multistage flowshop problem. Summarizing, the solution methodology combines the above approaches by feeding as an initial MIP upper bound the SA solution hence the solution time for the MIP is significantly deteriorated. Numerical results are obtained using real data and those results show each particular algorithm contribution. The solution methodology is part of a so-called Digital Twin (DT) framework and has been proposed as a tool for real-time optimization of production decision making, including scheduling. Enhancing the DT’s with state of the art scheduling algorithms that act in synergy with machine learning and simulation algorithms lies at the core of smart factories.

Strategic Decision Making in Trauma Systems

Eva K. Lee, The Data and Analytics Innovation Institute-Georgia Institute of Technology
Ahmet O. Ozlu, Georgia Institute of Technology, T-Mobile
Taylor J. Leonard, Georgia Institute of Technology-The United States Department of Air Force
Daniel Wood, Emory University Hospital Midtown

Trauma centers and trauma systems are vital community assets. A trauma system manages the treatment of severely injured people and spans the full spectrum of prevention and emergency care to recovery and rehabilitation. The National Study on the Costs and Outcomes of Trauma identified a 25% reduction in mortality for severely injured patients who received care at a Level I trauma center rather than at a non-trauma center. While most trauma-related studies concern the operational and tactical levels of trauma care and trauma systems, little attention has been given to a strategic level (top-down) approach to a trauma system from a financial/investment perspective. In this paper, we analyze a statewide trauma system and model it as a network of trauma facilities, hospitals, and emergency medical services (EMS). We develop a theoretical model and general-purpose computational framework that facilitates the allocation and utilization of resources by the statewide trauma system. Given a local trauma network profile, injury distribution, and resource requests, the modeling, and computational framework enable the creation of the set of all feasible and Pareto-efficient portfolios where limited available funding is allocated across numerous requests (investments) from trauma centers, hospitals, and EMS providers. Using the framework, decision-makers can quantitatively analyze the impact of each feasible portfolio on the trauma system's performance measures via the Trauma System Simulator. Sensitivity analysis can be conducted to determine the best decision/policy to transport/transfer patients and to observe how possible changes in system inputs affect the return on investment and resource utilization. Using the trauma system data in Georgia, our findings confirm that such dynamic and strategic resource allocation analyses empower decision-makers to make informed decisions that benefit globally the entire trauma network. The design is a top-down approach at a strategic level which simultaneously uses tactical-level decisions to evaluate several strategies to improve the system. Systems simulation-optimization is a powerful interlacing tool to perform a thorough analysis and systematic upgrade of a trauma system with given investments, which facilitates the decision-making process of trauma commission leaders.

Metaheuristic Algorithm Based on Tabu Search for Consistent Vehicle Routing Problem

Rodrigo Linfati, Department of Industrial Engineering, Universidad del Bío-Bío, Concepcion, Chile

Lucas Barros, School of Industrial Engineering, Universidad del Bío-Bío, Concepcion, Chile

Esteban Santana, School of Industrial Engineering, Universidad del Bío-Bío, Concepcion, Chile

John Willmer Escobar, Department of Accounting and Finance, Universidad del Valle, Cali, Colombia

The Vehicle Routing Problem (VRP) is a classic combinatorial optimization problem in operations research. It deals with the challenge of planning and scheduling the routes for a fleet of vehicles to serve a set of customers with known demands while minimizing the total distance traveled. However, the VRP often ignores the crucial aspect of customer satisfaction. To address this, the Consistent Vehicle Routing Problem (ConVRP) was introduced, which takes into account the consistency of service either by the time of service or the vehicle that offers the service. In recent years, metaheuristic algorithms have become popular for solving optimization problems due to their ability to quickly find high-quality solutions. Among these algorithms, tabu search is a widely used approach that is particularly effective for solving combinatorial optimization problems. In this context, a new variant of the ConVRP has been proposed, and a metaheuristic algorithm based on tabu search has been developed to solve it. The proposed algorithm was developed in the Julia programming language, while the mathematical model was developed using the AMPL programming language and solved using the commercial solvers CPLEX and Gurobi. To evaluate the performance of the proposed algorithm, experiments were conducted on structured instances by varying customer distribution (uniform or clustered), depot location, and arrival time to the customer. The experimental results demonstrate that the proposed metaheuristic algorithm based on tabu search is highly efficient in producing feasible solutions of high quality. The algorithm outperforms commercial solvers for the mathematical model in terms of computation times and is effective in solving ConVRP instances. The proposed algorithm provides an efficient and effective method for solving ConVRP, which considers the consistency of service, and offers feasible solutions of high quality in considerably less computation time than commercial solvers for the mathematical model. This is particularly relevant for real-world applications of vehicle routing problems.

Determining Asymmetry for Random Network Models

David Hartman, Computer Science Institute, Czech Academy of Sciences, Prague, Czech Republic- Charles University, Prague, Czech Republic

Jaroslav Hlinka, Computer Science Institute, Czech Academy of Sciences, Prague, Czech Republic- National Institute of Mental Health, Klecany, Czech Republic

Anna Pidnebesna, Computer Science Institute, Czech Academy of Sciences, Prague, Czech Republic- National Institute of Mental Health, Klecany, Czech Republic

Aneta Pokorná, Computer Science Institute, Czech Academy of Sciences, Prague, Czech Republic- Charles University, Prague, Czech Republic

Network symmetry has proven to be an important characteristic studied within complex networks [1]. Most symmetry characteristics are based on the automorphism group of the corresponding graph. Such a characteristic is quite sensitive to small changes in graph structures. Since complex networks are constructed from real-world data, their structure is influenced by potential uncertainty in the data. Recently, it has been suggested to use an alternative notion of approximate network symmetry [3]. This symmetry also considers the automorphism group but allows a small number of edges to break the isomorphism condition. The authors of the above-mentioned work suggested using simulated annealing to find the appropriate permutation minimizing problematic pairs of vertices. However, this approach has several drawbacks, such as the balance between the symmetry of the obtained solutions and the corresponding computational complexity or the inability of the suggested method to allow fixed points in the respective permutation. Searching for approximate automorphisms is closely related to the graph matching problem (GMP), which is known to be equivalent to a quadratic assignment problem (QAP). Recently, Vogelstein et al. [2] suggested a relaxation method to solve QAP. For such a relaxation it is possible to construct an iterative method that makes use of approaches from standard nonlinear solvers. In our work, we suggest a modification of the previously mentioned relaxed QAP (mrQAP) method for the estimation of the approximate network symmetry. The original relaxed QAP method allows having fixed points in the studied nodes' permutations. When computing the symmetry of a single graph, this method can converge to the identity solution, which is not desirable for our purposes. Thus, we penalize the number of fixed points in the suggested solution, which leads to finding approximately symmetrical non-identical permutations. We use extensive numerical simulations on random networks for the comparison of the algorithms. Compared to the simulated annealing approach, the suggested method mrQAP is computationally more efficient and improves the symmetry measure of the solutions.

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Augmented Lagrangian Method for Linear Programming Using Smooth Approximation

Fatemeh Bazikar, Department of Applied Mathematics, Faculty of Mathematical Sciences, University of Guilan, Rasht, Iran

Hossein Moosaei, Department of Informatics, Faculty of Science, Jan Evangelista Purkyně University, Ústí nad Labem, Czech Republic

Mujahid N. Seyed, Department of Industrial & Systems Engineering, Interdisciplinary Research Center for Intelligent Secure Systems, King Fahd University of Petroleum & Minerals, Dhahran, 31261, KSA, Saudi Arabia

Saeed Ketabchi, Department of Applied Mathematics, Faculty of Mathematical Sciences, University of Guilan, Rasht, Iran

Augmented Lagrangian method can be used for obtaining the least 2-norm solution of a linear program (LP). The main advantage of this approach is that it results in minimization of an unconstrained problem with piecewise quadratic, convex and differentiable objective function. Usage of exterior penalty function on LP's dual is proposed in [1]. The penalty function is piecewise, quadratic, convex, and differentiable. However, the ordinary Hessian does not exist for the function, which precludes the usage of Newton (second-order) method. However, since the penalty function's gradient is Lipschitz, a generalized Hessian exists [2], and these properties establish a finite global convergence of the generalized Newton method. In this work, we propose usage of the augmented Lagrangian method instead of the penalty function to solve LP in standard form. Instead of the generalized Newton method, we plan to use the smoothing techniques, and solve an auxiliary unconstrained smooth reformulation problem. The minimization problems are solved by the fast Newton method. The applicability of the proposed approach will be depicted on multiple LP examples.

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Using Data Mining Techniques to Analyze Facial Expression Motion Vectors

Mohamad Roshanzamir, Fasa University, Iran

Roohallah Alizadehsani, Deakin University, Australia

Mahdi Roshanzamir, University of Tabriz, Iran

Afshin Shoeibi, University of Granada, Spain

Juan M. Gorriz, University of Cambridge, United Kingdom

Abbas Khosravi, Deakin University, Australia

Saeid Nahavandi, Harvard University, United States

U Rajendra Acharya, University of Southern Queensland, Australia

Automatic recognition of facial expressions is a common problem in human-computer interaction. While humans can recognize facial expressions very easily, machines cannot do it as easily as humans. Analyzing facial changes during facial expressions is one of the methods used for this purpose by the machines. In this research, facial deformation caused by facial expressions is considered for automatic facial expression recognition by machines. To achieve this goal, the motion vectors of facial deformations are captured during facial expression using an optical flow algorithm. These motion vectors are then used to analyze facial expressions using some data mining algorithms. This analysis not only determined how changes in the face occur during facial expressions but can also be used for facial expression recognition. The facial expressions investigated in this research are happiness, sadness, surprise, fear, anger, and disgust. According to our research, these facial expressions were classified into 12 classes of facial motion vectors. We applied our proposed analysis mechanism to the extended Cohen-Kanade facial expression dataset. Our developed automatic facial expression system achieved 95.3%, 92.8%, and 90.2% accuracy using Deep Learning (DL), Support Vector Machine (SVM), and C5.0 classifiers, respectively. In addition, based on this research, it was determined which parts of the face have a greater impact on facial expression recognition.

A Numerical Scheme for a Generalized Fractional Derivative with Variable Order

Ricardo Almeida, Center for Research and Development in Mathematics and Applications, Department of Mathematics, University of Aveiro, Portugal

The aim of this paper is to present an approximation formula for the Caputo fractional derivative of variable order, with dependence on an arbitrary kernel. For special cases of this kernel function, or taking the fractional order being constant, we recover some known formulas. This numerical method involves only integer order derivatives, so any fractional problem can be approximated by an integer order problem. Some numerical simulations end the paper, showing the effectiveness of our procedure.

Assignment of Unexpected Tasks in Embedded System Design Process Using Genetic Programming

Adam Górski, Jagiellonian University, Poland

Maciej Ogorzałek, Jagiellonian University, Poland

Embedded systems need to execute some tasks. The designer needed to predict every behaviour of the system. However the problem appears when system meets unexpected situation. In some cases the system architecture cannot be modified or such operation is too expensive. In this paper we present a novel developmental genetic programming based method for assignment of unexpected tasks in embedded system design process. Our approach do not modify the system architecture. The proposed method evolves decision trees. The new individuals are obtained during evolution process after using genetic operators: mutation, crossover, cloning and selection. After genotype to phenotype mapping the ready system is obtained.

The Use of Artificial Intelligence in Supply Chain Project Management

Öncü Hazir, Supply Chain Management and Information Systems, Rennes School of Business France

Dirk H. Hartel, Service Management/Logistics and Supply Chain Management Baden-Wuerttemberg Cooperative State University Stuttgart, Germany

To manage projects, organizations can benefit from artificial intelligence (AI) techniques in various ways. We investigate the use of AI in supply chain project management (SCPM) in this research. We focus on the projects undertaken to enhance the effectiveness and resilience of the supply chain, such as investment projects to improve the supply chain network or digitalize procurement and logistic activities. AI promises considerable benefits in decision-making, specifically in planning, monitoring, and controlling these projects and performing risk assessments. To collect data, we conducted semi-structured interviews with experience or knowledge in project management (PM) and supply chain (SCM). We recorded their remarks on AI implementations in SCPM. More precisely, we wanted to understand the motives to adopt AI techniques, identify the type of techniques, the obstacles/enablers of adoption and implementation, the experiences in project life cycle management, and the impact of these tools on the success of the projects. Therefore, managers rather than organizations or projects are the unit of analysis in this research. We used an interview protocol with questions derived from this literature. The protocol includes questions, such as: For which purposes do you use or imagine using AI techniques in SCPM? In which project phases (project initiation, planning, execution, monitoring, closure) do you use AI techniques in SCPM? The interviewees have work experience in German organizations operating at various industries. All the interviewees underlined the added value of implementing AI techniques to manage supply chain problems. However, many of them believe that the use of AI in managing SC projects is minimal at very early stages of development. Our literature review found that most papers use AI in procurement and sourcing and use deep or machine learning. We investigated the practical applications in this research and tried to describe the current use and depict the future application areas. We discover the application areas and opportunities of using AI within SC projects based on a project life cycle management.

The Effects of Shift Generation on Staff Rostering

Kimmo Nurmi, Satakunta University of Applied Sciences, Satakunnankatu 23, 28130 Pori, Finland

Jari Kyngäs, University of Turku, 20014 Turun yliopisto, Finland

Nico Kyngäs, University of Turku, 20014 Turun yliopisto, Finland

To the best of our knowledge, this is the first paper to examine the effect of shift structures on staff rostering optimization. The study showed that the generated shift structures have a significant effect on optimizing the staff rosters. The study also showed that we should allow longer working days, because they imply better consideration of the stress and risk factors introduced by the Finnish Institute of Occupational Health. The PEASTP metaheuristic, a computational intelligence framework, was used to justify the findings. The results were obtained using a real-world instance from a Finnish contact center.

A Mixed-Integer Soft Sensor Development Algorithm

Hasan Sildir, Gebze Technical University, Turkey

Sahin Sarrafi, SOCAR Turkey R&D and Innovation Co., Turkey

Onur Can Boy, SOCAR Turkey R&D and Innovation Co., Turkey

Significant amount of online and offline data is collected from industrial and complex plants. The decision making based on such data requires selection and management of statistically contributing and easily measurable variables for the prediction of quality related variables which are obtained in relatively lower frequency and with significant delays due to laboratory issues. There are many methods to develop mathematical models, named as soft sensors, which deliver online predictions for such laboratory measurements. The accuracy and practical aspects of these soft sensors are important concerns due to product quality issues and plant maintenance.

This study focuses on the development of a mixed integer nonlinear programming (MINLP) problem to address the selection of a representative set of online measurements in addition to their lags. Those lags are calculated for each online measurement and delivers a better soft sensor performance since it explicitly introduces the time required for the mass transport from each sensor to the sample collection point. Moreover, the approach introduces binary variables into the formulation, in addition to traditional continuous parameters, to account for the existence of online measurements. The formulation is further tightened with linking constraints to ensure the zero-coefficients for the non-existent variables and narrow the search space for the optimization algorithm. The problem formulation is further modified to result in a mixed integer linear problem (MILP) by piece-wise linear representations of nonlinear expressions. Such an approach enables the selection of best theoretical subset of online measurements to deliver minimum prediction error. The overall method is flexible to different processes and problem related specific needs as more constraints are introduced to the formulation.

The methodology is implemented on an actual industrial distillation plant for the prediction of kerosene boiling point related quality variable and delivered approximately 25% better online performance compared to existing soft sensor. In addition, several optimization algorithms are compared in terms of CPU and accuracy for the solution of corresponding optimization problems.

Sensitivity Analysis in Linear Programming Revisited – A General Approach Involving Different Norms

Milan Hladík, Charles University, Faculty of Mathematics and Physics, Department of Applied Mathematics, Malostranské nám. 25, 11800, Prague, Czech Republic

The sensitivity analysis in linear programming is a notoriously known and in some sense standard technique that analyses how data variations influence the optimal value and the optimal solution. However, it has several shortcomings. The main of them is that it concerns variations of just one coefficient or a variation in a special direction. Therefore several extensions of the traditional sensitivity analysis were proposed. Among them, the tolerance approach to sensitivity analysis was developed to deal with independent and simultaneous variations of selected coefficients. Thus, it enables the decision maker to model more complex variations of the data. We go further and consider perturbations of possibly all input data. Given a matrix norm, our goal is to determine the maximum variation of the data in the norm such that the computed optimal basis remains optimal. First, we present general results valid for an arbitrary norm, and then we also analyse particular matrix norms such as the spectral and the maximum norm. Further, we study computational complexity of the problem and show for which norms the problem is polynomially computable and for which it is hard. For the intractable cases, we propose polynomially computable lower and upper bounds.

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A Quasi-extreme Reduction for Interval Transportation Problems

Elif Garajová, Charles University, Faculty of Mathematics and Physics, Department of Applied Mathematics, Prague, Czech Republic- Prague University of Economics and Business, Faculty of Informatics and Statistics, Department of Econometrics, Prague, Czech Republic

Miroslav Rada, Prague University of Economics and Business, Faculty of Informatics and Statistics, Department of Econometrics, Prague, Czech Republic- Prague University of Economics and Business, Faculty of Finance and Accounting, Department of Financial Accounting and Auditing, Prague, Czech Republic

Transportation problems provide a classic linear programming model used in many areas of operations research, such as inventory control, logistics or supply chain management. The goal of a transportation problem is to find a minimum-cost transportation plan for shipping a given commodity from a set of sources to a set of destinations. Since the input data of such models are not always known exactly in practice, we adopt the approach of interval programming, which handles uncertainty in the supply, demand and cost parameters by assuming that only lower and upper bounds on these quantities are given. One of the main tasks in interval programming is to compute bounds on the values that are optimal for some realization of the interval coefficients. While the best optimal value of an interval transportation problem can be computed by a single linear program, finding the worst (finite) optimal value is a much more challenging task. For interval transportation problems that are immune against the "more-for-less" paradox, it was recently proved that the worst optimal value can be found by considering only quasi-extreme scenarios, in which all coefficients in the model but one are set to the lower or upper bounds. We strengthen the former result and show that an analogous property also holds true for general interval transportation problems. Then, we utilize the obtained characterization to derive an exact method for computing the worst optimal value.

An Evolutionary Approach to Automated Class-Specific Data Augmentation for Image Classification

Silviu Marc, Middlesex University, United Kingdom

Roman Belavkin, Middlesex University, United Kingdom

David Windridge, Middlesex University, United Kingdom

Xiaohong Gao, Middlesex University, United Kingdom

Convolutional neural networks (CNNs) can achieve remarkable performance in many tasks of computer vision (e.g. classification, detection and segmentation of images). However, lack of labelled data can significantly hinder their generalization capabilities and limit the scope of their applications. Synthetic data augmentation (DA) is commonly used to address this issue, but uniformly applying global transformations can result in suboptimal performance when certain classes are more relevant to specific transformations. The success of DA can be improved by adopting class-specific data transformations. However, this leads to an exponential increase in the number of combinations of image transformations to choose from. Finding an optimal combination is challenging due to the large number of possible transformations (e.g. some augmentation libraries offering up to sixty default transformations) and training times of CNNs required to evaluate each combination. Here, we present an evolutionary approach using a genetic algorithm (GA) to search for an optimal combination of class-specific transformations subject to a feasible time constraint. Our study demonstrates a GA finding augmentation strategies that are significantly superior to a random baseline. We discuss and highlight the benefits of using class-specific data augmentation, how our evolutionary approach can automate the search for optimal DA strategies and how it can be improved.

A Spectral Projected Gradient in non-Cartesian Coordinate Spaces: a Case Study in Structural Biology

A. Mucherino, IRISA, University of Rennes, Rennes, France

J-H. Lin, RCAS and NBRP, Academia Sinica, Taipei, Taiwan

The Spectral Projected Gradient (SPG) is a method for constrained optimization problems, which can guarantee the optimality of the solutions for convex problems, and that was already used in a large variety of applications. We focus on problems arising in the context of structural biology, where SPG was already successfully employed. In this work, we study the possibility to replace the traditional representation of the solutions, given as sets of Cartesian coordinates, with an alternative representation making use of the torsion angles that we can define along the protein backbones. This has an impact on the objective function of the original optimization problem, and hence on the gradient of the function. Our approach involves a transformation from torsion angles to Cartesian coordinates, which we perform by using dual numbers for an automatic differentiation of the used transformation. Preliminary computational experiments show the accuracy of this new approach.

Improving Handwritten Cyrillic OCR by Font-based Synthetic Text Generator

Ivan Gruber, Department of Cybernetics and New Technologies for the Information Society, University of West Bohemia, Czech Republic

Lukáš Picek, Department of Cybernetics and New Technologies for the Information Society, University of West Bohemia, Czech Republic

Miroslav Hlaváč, Department of Cybernetics and New Technologies for the Information Society, University of West Bohemia, Czech Republic

Petr Neduchal, Department of Cybernetics and New Technologies for the Information Society, University of West Bohemia, Czech Republic

Marek Hruz, Department of Cybernetics and New Technologies for the Information Society, University of West Bohemia, Czech Republic

In this paper, we propose a straight-forward and effective Font-based Synthetic Text Generator (FbSTG) to alleviate the need for annotated data required for not just Cyrillic handwritten text recognition. Unlike standard GAN-based methods, the FbSTG does not have to be trained to learn new characters and styles; all it needs is the fonts, the text, and sampled page backgrounds. In order to show the benefits of the newly proposed method, we train and test two different OCR systems (Tesseract, and TrOCR) on the Handwritten Kazakh and Russian dataset (HKR) both with and without synthetic data. Besides, we evaluate both systems' performance on a private NKVD dataset containing historical documents from Ukraine with a high amount of out-ofvocabulary (OoV) words representing an extremely challenging task for current state-of-the-art methods. We decreased the CER and WER significantly by adding the synthetic data with the TrOCR-Base-384 model on both datasets. More precisely, we reduced the relative error in terms of CER / WER on (i) HKR-Test1 with OoV samples by around 20% / 10%, and (ii) NKVD dataset by 24% CER and 8% WER. The FbSTG code is available at: https://github.com/mhlzcu/doc_gen.

A Pseudopolynomial Algorithm for the Worst Min-Cost Flow with Uncertain Capacities

Miroslav Rada, Prague University of Economics and Business, Faculty of Informatics and Statistics, Department of Econometrics, Prague, Czech Republic- Prague University of Economics and Business, Faculty of Finance and Accounting, Department of Financial Accounting and Auditing, Prague, Czech Republic

Lets generalize the classical min-cost flow problem. Restate the problem here: given a graph with two special nodes, source and sink, equipped with two valuations on each edge, a unit cost and a capacity, find a way to transport a given amount of flow from source to sink such that the total costs are minimal and no capacity on an edge is violated. In the generalized setup, assume that the capacities are not given as crisp values, they rather come from a set of possible scenarios, which might be e.g. an interval box, and the goal is to find a feasible scenario with the worst minimal costs. From the optimization viewpoint, the problem can be modelled as a bilevel program. Bad news is that the problem is strongly-NP-hard. But there is even more unpleasant finding: it is strongly-NP-hard also for special classes of graphs, namely for directed acyclic graphs, and even worse, also a) for series-parallel graphs (SPG), for which some hard problems on graphs (e.g. finding the longest path) become easier, and b) for graphs with only small (linear in number of edges) number of paths from the source to the sink. Aside from the above mentioned results, this talk is focused on some good news: despite the NP-hardness, there is a pseudopolynomial algorithm for SPG. The algorithm follows the construction of SPG by the primitive operations (arc-creation, parallel composition and series composition) and can possibly be extended to handle also other forms of uncertainty.

Design of a New Control Loop Using HYSYS Dynamic

Hocine Meglouli, University of Boumerdes, Algeria

Abdelmalek Khebli, University of Boumerdes, Algeria

In addition to the development of a DCS based control System, good continuous control is needed to maintain some parameters at desired values, these parameters are mainly machine speed and pressure trough it (at the inlet or at the outlet, it depends on the purpose). Machine speed is critical for good performances and availability of the turbo-expander, 'over speed' is a trip factor which shuts down the machine and causes production loss (as explained in the second chapter) and speeds above the design operational value can cause troubles with lube oil and bearings température, in addition to this, 'excessive vibrations' which is also a trip factor results, from oscillatory behavior of the different parameters.

In the same way pressure is also critical to the good conduct of the process, a drift in a parameter can affect the efficiency of the expander or the outlet temperature of the gas, consequently this will have impact on the extraction of liquids.

Due to the unsatisfactory performances of the existing control loop, we have been proposed to design a new loop which will meet most of the requirements needed to maintain good rates of liquids extraction and to ensure maximum availability and reliability of the turbo-expander.

The design was based on the simulation models offered by the powerful petrochemicals and gas equipment simulator : ASPEN HYSYS . The high fidelity and flexibility of the software in addition to its dynamic simulation mode hâve motivated us to select it among the existing simulators in the market.

Consumers Financial Distress: Prediction and Prescription Using Machine Learning

Serge Nyawa, TBS Business School, France

Hendrik de Waal, Johannesburg Business School, South Africa

Samuel Fosso Wamba, TBS Business School, France

This paper shows how transactional bank account data can be used to predict and prevent financial distress in consumers. Machine learning methods were used to understand the most significant transactional behaviours that cause financial distress. We show that Gradian Boosting outperforms the other machine learning models when predicting the financial distress of a consumer. We also obtained that Fees, Uncategorised transactions, Other Income, Transfers, Groceries, and Interest paid were sub-categories of transactions that highly impacted the financial distress risk. The study also proposes prescriptions that can be communicated to the client to help the individual make better financial decisions and improve their financial well-being by not entering a state of financial distress. This research used data from a major South African bank, and the study was limited to credit card clients.

Building Trust in Video Classification

Konstantinos Tarkasis, University of Macedonia, Greece

Konstantinos Kaparis, University of Macedonia, Greece

Andreas Georgiou, University of Macedonia, Greece

We propose a method for the dynamic evaluation of the output given by any Real Time Object Detection Algorithms. Our objective is the enhancement of the process with regards to its so-called trust- worthiness and is based on the spatial consideration of the sequence of frames that are fed as inputs on a Convolutional Neural Network (CNN). A suitable classification method (DBscan) is employed and clusters the sequential outputs of the used CNN based on similarity metrics and it evaluates the quality of the results returned by any CNN in a methodologically agnostic fashion. An extensive set of com- putational results demonstrates the effectiveness and potentials of the proposed method.

An Exact Parallel Method for a Bi-Objective Knapsack Problem

Younes DJELLOULI, AMCD-RO Laboratory, DGRSDT, USTHB, Faculty of Mathematics, Department of Operations Research, B.P. 32 El-alia, Bab Ezzouar, Algiers 16111, Algeria

In the present conference, we propose a parallel implementation of an exact two-phase technique on a CPU-GPU system to solve the bi-objective knapsack problem. We apply the Branch-and-Bound approach in both phases and a very efficient reduction technique to generate all efficient solutions. In the first phase, we search for all supported efficient extreme solutions before using an efficiency reduction approach to reduce the problem size. All non-supported efficient solutions are produced in the second phase. Then, an algorithm combining the three procedures is developed and written in the CUDA programming language. We study the performance impact of parallel computing on a series of numerical examples in comparison with other specific techniques reported in the literature. The efficiency of the suggested parallel solution strategy is also tested on uncorrelated instances (strong instances), allowing us to corroborate it.

A Risk-Cost Analysis for an Increasingly Widespread Monitoring of Railway Lines

Imma Lory Aprea, Department of Economics, Law, Cybersecurity and Sports Sciences, University of Naples "Parthenope", Guglielmo Pepe Street, 80035 Nola, Italy

Chiara Donnini, Department of Business and Quantitative Studies, University of Naples "Parthenope", Generale Parisi Street, 80132 Naples, Italy

Federica Gioia, Department of Business and Quantitative Studies, University of Naples "Parthenope", Generale Parisi Street, 80132 Naples, Italy

Structural Health Monitoring represents an essential tool for detecting timely failures that may cause potential damage to the railway infrastructure, such as extreme weather conditions, natural accidental phenomena and heavy loads affecting tracks, bridges and other structures over time. Hence, mathematical models to optimally plan railway infrastructure maintenance, starting from a cost-benefit analysis, are required. In this paper, we propose an optimal approach to ensure the maximum railway infrastructure reliability through increasingly widespread and effective monitoring, subject to a budget constraint. More in detail, considered a network of zones, each of which is monitored by a set of fixed diagnostic sensors, our goal is to identify new additional areas in which to place the same set of sensors in order to evaluate the geometric and structural quality of the track simultaneously. Each decision criterion has to involve an analysis of monitoring and non-monitoring costs. Our proposal suggests considering them both depending on the risk level of the occurrence of the extreme phenomena under investigation. A descriptive analysis of the procedure, which may be used to identify the additional zones, is provided in the paper by illustrating the resolution algorithm of the problem.

Strengthening Network Security and Resilience Through Critical Node Detection and Analysis

Essia Hamouda, California State University San Bernardino, United States

As our reliance on interconnected technologies continues to grow, cybersecurity threats are becoming increasingly prevalent. Cyber attackers typically focus on specific nodes in communication networks, known as critical nodes. Such nodes can severely impact network performance and functionality if they fail or act maliciously. For example, an attack on an essential internet service provider such as AT&T or Sprint [1] servers could cause widespread disruptions to millions of businesses' websites and online services. Unusual traffic patterns in a network may also indicate that a computer or a critical node has been hacked, and data is being transmitted to unauthorized destinations, or that a computer is undergoing a denial-of-service attack. Identifying critical nodes in a network has received significant attention in the literature, particularly regarding their connectivity-related importance. The failure of specific nodes in a network can lead to significant consequences, such as connectivity issues, decreased network size, and potential security threats. Therefore, it is crucial to proactively monitor critical nodes and implement appropriate security measures to prevent or mitigate such attacks to maintain normal network functions.

This paper explores the identification and analysis of critical nodes in communication networks to improve network security and robustness. We propose a greedy approach that identifies and ranks critical nodes based on several centrality measures, including degree, betweenness, closeness, and eigenvector. We further extend the method to a more efficient greedy method that alters the network by removing critical node. We evaluate and compare our proposed methods to each other and to other existing methods in the literature. Our experimental results demonstrate that our proposed methods are efficient, computationally attractive, and provide valuable insights into network analysis. Additionally, we introduce a new method to estimate the probability of a critical node being compromised, based on the aforementioned measures. By analyzing the likelihood values, we gain valuable insights into the network's security and robustness against external threats. Furthermore, to achieve a desired level of network robustness while maintaining a node's security level, we assign critical nodes a security level that is measured in terms of a resource level that needs to be expended to decrease the probability of failure of a particular critical node. We then model the network as a nonlinear optimization problem subject to a budget constraint. Our objective is to determine the optimal security level to assign to these critical nodes given a desired level of network robustness. We believe that such tools and results are useful for network administrators to make informed decisions.

[1] https://www.cbsnews.com/sanfrancisco/news/thousands-of-t-mobile-verizon-sprint-att-customers-experience-cellphone-outages-nationwide-denial-of-service-ddos-cyberattack/

Iranian Architectural Styles Recognition Using Image Processing and Deep Learning

Mohammad Tayarani Darbandy, School of Architecture, Islamic Azad University Taft, Taft 8991985495, Iran

Benyamin Zojaji, Sadjad University, Mashhad, Iran

Fariba Alizadeh Sani, Mashhad University of Medical Science, Mashhad, Iran

Iranian architecture or Persian architecture is the design of buildings of Iran and parts of the rest of West Asia, the Caucasus, and Central Asia. Its history with its unique characteristics goes back to at least 5,000 BC. As regards, Iran is located in the Middle East and the Middle East is in danger of possible wars, such as Iraq, Afghanistan, and Syria. Always during war, some historical monuments are unintentionally damaged or bombed and easily destroyed or suffer a lot of damage, and since the historical monuments of each country belong to all the people of the world, so weed to try to preserve them. In this paper, we propose a system for the automatic detection and recognition of Monuments based on Deep Learning methods. This system can be activated on the attacker's war equipment and the attacker can find out the date of construction of the building according to its architectural style and receive the necessary warning not to target the building. We have also prepared a dataset with about 3000 photos according to six styles of Iranian architecture of Iranian historical monuments that can be used in other sciences and applications. Also, this way can be helpful for tourists to familiarize themselves with Iranian historical monuments without the need of a guide to present by using cellphone photos to get information about the period of the historical monument and the style of that architectural building.

Optimizing Classroom Assignments to Reduce Non-Essential Interactions Among University-Level Students During Pandemics

Mujahid N. Syed, Department of Industrial & Systems Engineering, Interdisciplinary Research Center for Intelligent Secure Systems, King Fahd University of Petroleum & Minerals, Dhahran, 31261, KSA, Saudi Arabia

Academic sectors involve students from multiple origins, multiple social circles, and different health conditions. During pandemics like COVID-19, a key challenge is to reduce non-essential interactions among students while they are at school/university. In this work, we focus on interactions that occur when university level students move between consecutive classes. Specifically, the interactions that arise during the movements of students between different university buildings via buses or cars. These type of movements are very critical during the pandemic because they are inevitable, occur simultaneously & periodically, and have a small time window (10 to 15 minutes). Movement via buses is a hot spot for spreading viral diseases like COVID-19. Furthermore, high usage of cars/bikes during the 10 to 15 minutes class interval results in high traffic on campus roads, which in-turn leads to longer travel times of the buses (due to the road congestion). Nevertheless, having consecutive classes within walkable range may reduce the above interactions. To sum, careful assignment of classrooms to courses reduces the above nonessential interactions. In this work, we present an operations research based approach that assigns classroom locations to courses such that the overall interactions are minimized. Specifically, we propose a novel mixed integer program (MIP) that minimizes the above interactions. Numerical case study is provided to showcase the effectiveness of the proposed MIP.

Why and how to optimize in power generation

Urban Kravjanský, ČEZ Group, Prague, Czech Republic

Optimisation of power generation on the free market is a complex task. Presentation aims to address why the complexity is present and how it can be tackled. Some of the possible approaches are mentioned, from historically used through current to possible future ones. Their benefits and issues found in real life during ongoing in-house optimisation models re-design are also touched.